CLAIMS

I/We claim:

[c1] 1. An integrated tool for wet chemical processing of microfeature workpieces, comprising:

a frame;

a mounting module at least partially positioned within the frame, the mounting module having a plurality of positioning elements and attachment elements;

a workpiece support carried by the mounting module;

a wet chemical processing chamber carried by the mounting module, the processing chamber having a first interface member engaged with one of the positioning elements and a first fastener engaged with one of the attachment elements, the processing chamber further having a vessel with a process location positioned to receive a microfeature workpiece, and a paddle device positioned at least proximate to the process location, the paddle device having at least one paddle, at least one of the paddle device and the workpiece support being movable relative to the other;

a transport system carried by the mounting module for transporting workpieces within the tool, the transport system having a second interface member engaged with one of the positioning elements and a second fastener engaged with one of the attachment elements; and

wherein the mounting module is configured to maintain relative positions between positioning elements such that the transport system does not need to be recalibrated when the processing chamber is replaced with another processing chamber.

[c2] 2. The tool of claim 1 wherein the mounting module includes a deck comprising:

a rigid outer member, wherein at least some of the positioning elements and at least some of the attachment elements are on the outer member;

a rigid interior member juxtaposed to the outer member;

bracing between the outer member and the interior member, wherein the outer member, the bracing, and the interior member are fastened together; and

wherein the wet chemical processing chamber is attached to the deck.

[c3] 3. The tool of claim 1 wherein the mounting module includes a deck comprising:

a rigid first panel, wherein at least some of the positioning elements and at least some of the attachment elements are on the first panel;

a rigid second panel juxtaposed to the first panel;

braces between the first and second panels, wherein the first panel, the braces and the second panel are fastened together to be dimensionally stable; and

wherein the wet chemical processing chamber is attached to the deck.

[c4] 4. The tool of claim 1 wherein the mounting module includes a deck comprising:

a plurality of joists;

a rigid first panel attached to one side of the joists and having at least some of (a) the positioning elements and (b) the attachment elements;

a rigid second panel juxtaposed to the first panel and attached to another side of the joists; and

wherein the wet chemical processing chamber is attached to first panel of the deck.

[c5] 5. The tool of claim 1 wherein the mounting module further comprises:

a processing deck comprising an upper panel, a lower panel under the upper panel and braces attached between the upper and lower panels, the upper panel having at least some of (a) the positioning elements and (b) the attachment elements, wherein the first interface member of the wet chemical processing chamber is engaged with a corresponding positioning element of the upper panel of the processing deck; and

a platform having at least some of the positioning elements and being fixedly disposed in the tool relative to the processing deck, and wherein the second interface member of the workpiece transport mechanism is engaged with a corresponding positioning element of the platform.

[c6] 6. The tool of claim 1 wherein the mounting module comprises a deck for carrying the wet chemical processing chamber, a platform for carrying the transport system, and adjustable footings for adjustably attaching the mounting module to the frame, and wherein:

the deck comprises a plurality of joists, a rigid first panel attached to one side of the joists and having a first set of the positioning elements and a first set of the attachment elements, and a rigid second panel juxtaposed to the first panel and attached to another side of the joists;

the platform comprises a second set of positioning elements and a second set of attachment elements;

the wet chemical processing station is carried by the deck and includes a plurality of first interface members and a plurality of first fasteners,

and the first interface members being engaged with corresponding positioning elements of the first set of positioning elements and the first fasteners being engaged with corresponding attachment elements of the first set of attachment elements; and wherein

the transport system is carried by the platform and includes a plurality of second interface members and a plurality of second fasteners, and the second interface members being engaged with corresponding positioning elements of the second set of positioning elements and the second fasteners being engaged with corresponding attachments elements of the second set of attachment elements.

[c7] 7. The tool of claim 1 wherein:

the wet chemical processing chamber is a first electrochemical deposition chamber comprising a first vessel, a first workpiece support disposed relative to the first vessel to hold a workpiece in a processing solution, a first cathodic electrode disposed in one of the first vessel or the first workpiece support, and a first anodic electrode disposed in the other of the first vessel or the first workpiece support; and wherein

the tool further comprises a second electrochemical deposition chamber comprising a second vessel, a second workpiece support disposed relative to the second vessel to hold a workpiece in a processing solution, a second cathodic electrode disposed in one of the second vessel or the second workpiece support, and a second anodic electrode disposed in the other of the second vessel or the second workpiece support.

[c8] 8. The tool of claim 1 wherein:

the wet chemical processing chamber is a first electrochemical deposition chamber comprising a first vessel, a first workpiece support

disposed relative to the first vessel to hold a workpiece in a processing solution, a first cathodic electrode disposed in one of the first vessel or the first workpiece support, and a first anodic electrode disposed in the other of the first vessel or the first workpiece support; and wherein

the tool further includes a second wet chemical processing chamber comprising a cleaning chamber having a fluid delivery system that directs a cleaning fluid onto a workpiece.

[c9] 9. The tool of claim 1 wherein the mounting module is configured to maintain relative positions between the positioning elements to within 0.025 inch.

[c10] 10. The tool of claim 1 wherein the mounting module is configured to maintain relative positions between the positioning elements to within approximately 0.005 to 0.015 inch.

[c11] 11. The tool of claim 1, further comprising a controller operatively coupled to the at least one of the paddle device and the workpiece support, the controller being configured to move the at least one of the at least one paddle device and the workpiece support relative to the other in a reciprocal manner along a generally linear axis, with a stroke of the relative motion changing between at least two successive reciprocations.

[c12] 12. The tool of claim 1, further comprising a paddle chamber in fluid communication with the vessel, the paddle chamber having an opening at the process location to receive a microfeature workpiece, the paddle chamber having a base portion facing the process location and being spaced apart from the process location by a first distance along a first axis generally normal to the process location and wherein the at least one paddle extends for a second

distance generally parallel to the first axis, the second distance being at least 70% of the first distance.

[c13] 13. The tool of claim 1 wherein the paddle device includes a plurality of paddles having spaced apart paddle surfaces and being reciprocally movable relative to the process location along a generally linear motion axis.

[c14] 14. The tool of claim 1, further comprising a magnet positioned proximate to the process location to orient material deposited on a microfeature workpiece at the process location.

[c15] 15. The tool of claim 1, further comprising:

a magnet positioned at least proximate to the process location, the magnet being positioned to impose a magnetic field at the process location to orient material deposited on a microfeature workpiece; and

an electrode support positioned to carry at least one electrode in fluid communication with the process location, the electrode support being movable relative to the vessel between a process position and a removed position along a motion path that does not pass through the process location.

[c16] 16. The tool of claim 1 wherein the at least one paddle has a first surface and a second surface facing opposite from the first surface, the first and second surfaces being canted outwardly and downwardly away from an axis positioned between the surfaces and normal to the process location.

[c17] 17. The tool of claim 1 wherein the at least one paddle is at least partially transmissive to the processing fluid to allow the processing fluid to pass through the at least one paddle as a result of relative motion between the at least one paddle and the workpiece support.

[c18] 18. The tool of claim 1 wherein the paddle device includes a first paddle and a second paddle, with at least a portion of the second paddle being spaced apart from the first paddle, the first paddle having a first shape and size and the second paddle having a second shape and size, with the first shape being different than the second shape, or the first size being different than the second size, or both.

[c19] 19. The tool of claim 1 wherein the process location includes a portion of a generally planar process plane, and wherein the tool further comprises an electrode support positioned to carry a thieving electrode remote from the process plane.

[c20] 20. The tool of claim 1, further comprising an electrode support positioned to be in fluid communication with the process location, the electrode support having a plurality of electrode chambers at least partially separated from each other by dielectric barriers, with gaps between the dielectric barriers forming a corresponding plurality of virtual electrode locations spaced apart from the process location.

[c21] 21. The tool of claim 1 wherein the workpiece support is positioned to rotate a microfeature workpiece at the process plane about an axis generally normal to the process plane.

[c22] 22. The tool of claim 1, further comprising:

an electrode support configured to carry at least one electrode, the electrode support being in fluid communication with the process location; and

an electric field control element positioned along a flow path between the electrode support and the process location, the electric field control element being configured control an electrical current density in the

processing fluid at the process location to have a first value at a first circumferential site of the process location and a second value different than the first value at a second circumferential site of the process location.

[c23] 23. An integrated tool for wet chemical processing of microfeature workpieces, comprising:

a mounting module comprising a deck having a rigid outer member with a plurality of positioning elements and a plurality of attachment elements, a rigid interior member juxtaposed to the outer member, and bracing between the outer member and the interior member, wherein the outer member, the bracing and the interior member are fixed together to be dimensionally stable;

a wet chemical processing station attached to the deck, the wet chemical processing station having a first interface member engaged with at least one of the positioning elements and a first fastener engaged with an attachment element, the wet chemical processing station further including a vessel having a process location positioned to receive a microfeature workpiece, and a paddle device positioned at least proximate to the process location, the paddle device having at least one paddle and being movable relative to the process location; and

a workpiece transport system attached to the mounting module.

[c24] 24. The tool of claim 23 wherein the outer member is superimposed over the interior member, and the deck further comprises a plurality of bolts clamping the outer member to one side of the bracing the clamping the interior member to another side of the bracing.

[c25] 25. The tool of claim 23 wherein the bracing comprises horizontal joists, the outer member comprises a rigid top panel attached to a top side of the joists, the interior member comprises a bottom panel superimposed under the top panel and attached to an underside of the joists, and the deck further comprises a plurality of bolts extending through the bracing to clamp the top panel and the bottom panel to the joists.

[c26] 26. The tool of claim 23 wherein the top panel, the joists, and the bottom panel are configured to maintain relative positions between the positioning elements across the top panel to within 0.025 inch.

[c27] 27. The tool of claim 23, further comprising a paddle chamber in fluid communication with the vessel, the paddle chamber having an opening at the process location to receive a microfeature workpiece, the paddle chamber having a base portion facing the process location and being spaced apart from the process location by a first distance along a first axis generally normal to the process location and wherein the at least one paddle extends for a second distance generally parallel to the first axis, the second distance being at least 70% of the first distance.

[c28] 28. The tool of claim 23, further comprising:

a magnet positioned at least proximate to the process location, the magnet being positioned to impose a magnetic field at the process location to orient material deposited on a microfeature workpiece; and

an electrode support positioned to carry at least one electrode in fluid communication with the process location, the electrode support being movable relative to the vessel between a process position and a removed position along a motion path that does not pass through the process location.

[c29] 29. The tool of claim 23 wherein the paddle device includes a first paddle and a second paddle, with at least a portion of the second paddle being spaced apart from the first paddle, the first paddle having a first shape and size and the second paddle having a second shape and size, with the first shape being different than the second shape, or the first size being different than the second size, or both.

[c30] 30. The tool of claim 23, further comprising an electrode support positioned to be in fluid communication with the process location, the electrode support having a plurality of electrode chambers at least partially separated from each other by dielectric barriers, with gaps between the dielectric barriers forming a corresponding plurality of virtual electrode locations spaced apart from the process location.

[c31] 31. The tool of claim 23, further comprising:

an electrode support configured to carry at least one electrode, the electrode support being in fluid communication with the process location; and

an electric field control element positioned along a flow path between the electrode support and the process location, the electric field control element being configured control an electrical current density in the processing fluid at the process location to have a first value at a first circumferential site of the process location and a second value different than the first value at a second circumferential site of the process location.

[c32] 32. A method of operating an integrated tool for wet chemical processing of microfeature workpieces having submicron features, comprising:

processing a microfeature workpiece in a wet chemical processing chamber by contacting a processing fluid with the microfeature

workpiece at a process location and agitating the processing fluid by moving at least one of the workpiece and a paddle device positioned proximate to the workpiece relative to the other, the paddle device having at least one paddle, the wet chemical processing chamber being located at a first position in the tool;

removing the wet chemical processing chamber from the tool;

replacing the wet chemical processing chamber with a replacement wet chemical processing chamber by mounting the replacement wet chemical processing chamber to the tool at the first position; and

loading another microfeature workpiece in the replacement wet chemical processing using an automated workpiece transport system without calibrating the automated workpiece transport mechanism after replacing the wet chemical processing station.

[c33] 33. The method of claim 32 wherein removing the wet chemical processing chamber from the tool includes disengaging the wet chemical processing chamber from positioning elements and attachment elements of the tool, and wherein replacing the wet chemical processing chamber with a replacement wet chemical processing chamber includes engaging the replacement wet chemical processing chamber with the positioning elements and attachment elements.

[c34] 34. The method of claim 32 wherein the process location includes a portion of a generally planar process plane, and wherein processing the microfeature workpiece includes placing the microfeature workpiece in fluid communication with at least one electrode to electrolytically deposit a magnetically sensitive material on the microfeature workpiece while the microfeature workpiece is subjected to a magnetic field at the process plane and while the microfeature workpiece is in fluid communication wit the at least one electrode, and wherein the method further comprises removing the at least one

electrode from fluid communication with the process plane without passing the at least one electrode through the process plane.

[c35] 35. The method of claim 32 wherein processing the microfeature workpiece includes electrolytically depositing a material on the microfeature workpiece by directing at least a portion of the processing fluid toward the microfeature workpiece and adjacent to a plurality of electrodes positioned in a plurality of electrode chambers at least partially separated from each other by dielectric barriers, with gaps between the dielectric barriers forming a corresponding plurality of virtual electrode locations spaced apart from the process location.

[c36] 36. The method of claim 32 wherein the microfeature workpiece has a maximum width and wherein the method further comprises reciprocating at least one of the microfeature workpiece and the at least one paddle relative to the other along a generally linear motion path, with each of at least two temporally adjacent strokes of the motion covering a distance less than the maximum width.

[c37] 37. The method of claim 32, further comprising:

reciprocating at least one of the microfeature workpiece and the at least one paddle relative to the other along a generally linear axis; and

changing a reciprocal motion of the at least one of the microfeature workpiece and the at least one paddle so that at least one stroke of the reciprocal motion covers an envelope different than an envelope covered by a subsequent stroke.

[c38] 38. A method of operating a wet chemical processing tool having a mounting module with a rigid deck including positioning elements and attachment elements, a plurality of wet chemical processing chambers having interface members engaged with corresponding positioning elements and fasteners

engaged with corresponding attachment elements, and a workpiece transport system attached to the mounting module for transporting microfeature workpieces having submicron features to/from the wet chemical processing chambers, the method comprising:

removing one of the wet chemical processing chambers from the mounting module by disengaging interface members from corresponding positioning elements and detaching fasteners from corresponding attachment elements to vacate a processing station;

mounting a replacement wet chemical processing chamber having interface members to the vacated processing station by engaging interface members of the replacement wet chemical processing chamber with corresponding positioning elements at the vacated processing station, the replacement wet chemical processing chamber being configured to receive a processing fluid, the replacement wet chemical processing chamber having a process location positioned to receive a microfeature workpiece, the replacement wet chemical processing chamber further having a paddle device with at least one paddle, at least one of the microfeature workpiece and the at least one paddle being movable relative to the other to agitate the processing fluid at the process location; and

operating the transport system to load a microfeature workpiece in the replacement wet chemical processing chamber without calibrating the transport system after mounting the replacement wet chemical processing chamber.

[c39] 39. The method of claim 38, further comprising electrolytically depositing a material on a microfeature workpiece in the replacement wet chemical processing chamber by directing at least a portion of the processing fluid toward the microfeature workpiece and adjacent to a plurality of electrodes positioned in a plurality of electrode chambers at least partially separated from

each other by dielectric barriers, with gaps between the dielectric barriers forming a corresponding plurality of virtual electrode locations spaced apart from the process location.

[c40] 40. The method of claim 38, further comprising:

reciprocating at least one of the microfeature workpiece and the at least one paddle relative to the other along a generally linear axis; and

changing a reciprocal motion of the at least one of the microfeature workpiece and the at least one paddle so that at least one stroke of the reciprocal motion covers an envelope different than an envelope covered by a subsequent stroke.